A New Cryocooler for MgB2 Superconducting Systems in Turboelectric Aircraft, Phase II Project

SBIR/STTR Programs | Space Technology Mission Directorate (STMD)

ABSTRACT

Turboelectric aircraft with gas turbines driving electric generators connected to electric propulsion motors have the potential to transform the aircraft design space by decoupling power generation from propulsion. Resulting aircraft designs such as blended-wing bodies with distributed propulsion can provide the large reductions in emissions, fuel burn, and noise required to make air transportation growth projections sustainable. The power density requirements for these electric machines can only be achieved with superconductors, which in turn require lightweight, high-capacity cryocoolers. Creare has previously developed a Cryoflight turbo-Brayton cryocooler concept that exceeds the mass and performance targets identified by NASA for superconducting aircraft with high-temperature superconducting (HTS) materials requiring cooling to 50 K. Here, we extended the temperature range of our cryocooler with an innovative new cycle concept to provide cooling to 20 K for MgB2 superconductors, which offer price and performance advantages for certain superconducting machines. In Phase I of this project, we evaluated the performance advantages of our concept through modeling and preliminary component designs. In Phase II, we will fabricate and test the highest-risk components to bring the overall TRL to 4. In Phase III, we will build and test a complete cryocooler to support extended performance testing with MgB2 systems. This development effort will provide an enabling technology for the superconducting systems needed to make turboelectric aircraft feasible.

ANTICIPATED BENEFITS

To NASA funded missions:

Potential NASA Commercial Applications: Our proposed cryocooler development effort will support NASA?s long-term goal to increase aircraft efficiency and reduce aircraft emissions and noise. By providing a cryocooler capable of cooling MgB2

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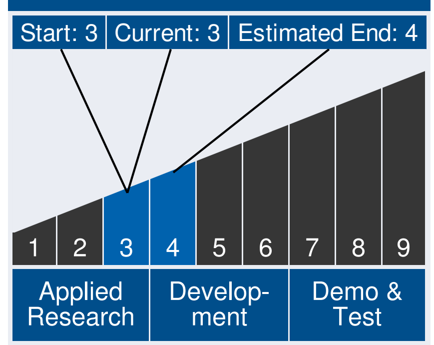
Technology Maturity



Management Team

Program Executives:
- Joseph Grant
- Laguduva Kubendran

Program Manager:
- Carlos Torrez

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systems and optimized to meet the aggressive power density target required for aircraft, we will enable an alternative approach to HTS systems and allow a detailed evaluation of the relative advantages of HTS and MgB2 superconducting technologies. Such an evaluation is needed to clarify the road map for superconducting aircraft. While such aircraft are still two or three decades from production, supporting technology development needs to begin now if such aircraft are to become a viable alternative to the aircraft configurations in production today. The results of this SBIR project will support continuing NASA design trade studies, system demonstrations, and eventual superconducting aircraft demonstrations. Other NASA applications include space applications such as hydrogen cryogenic liquefaction and zero-boil-off storage for in-space propellant depots, planetary and extraterrestrial exploration missions, CEVs, extended-life orbital transfer vehicles and extraterrestrial bases. Terrestrial NASA applications include cooling for spaceport cryogen storage and transportation systems and for demonstration hydrogen production and transportation systems. The highly reliable and space-proven turbo-Brayton cryocooler is ideal for these applications.

To the commercial space industry:

Potential Non-NASA Commercial Applications: Superconducting materials have the potential to revolutionize the way we generate, transmit, and consume power. Transformational initiatives that rely on superconducting technologies include power conditioning and power transmission systems, large-scale offshore wind turbines, high efficiency data centers, Navy ship systems, and turboelectric aircraft. While the latter is the target application for the proposed cryocooler, the other applications represent potential near-term markets for the technology. Companies are currently pursuing approaches based on either HTS or MgB2 superconducting materials. The low-temperature cryocooler proposed here will support MgB2 systems, which offer a number of advantages over HTS systems including lower cost and reduced losses in varying magnetic fields. The 20 K

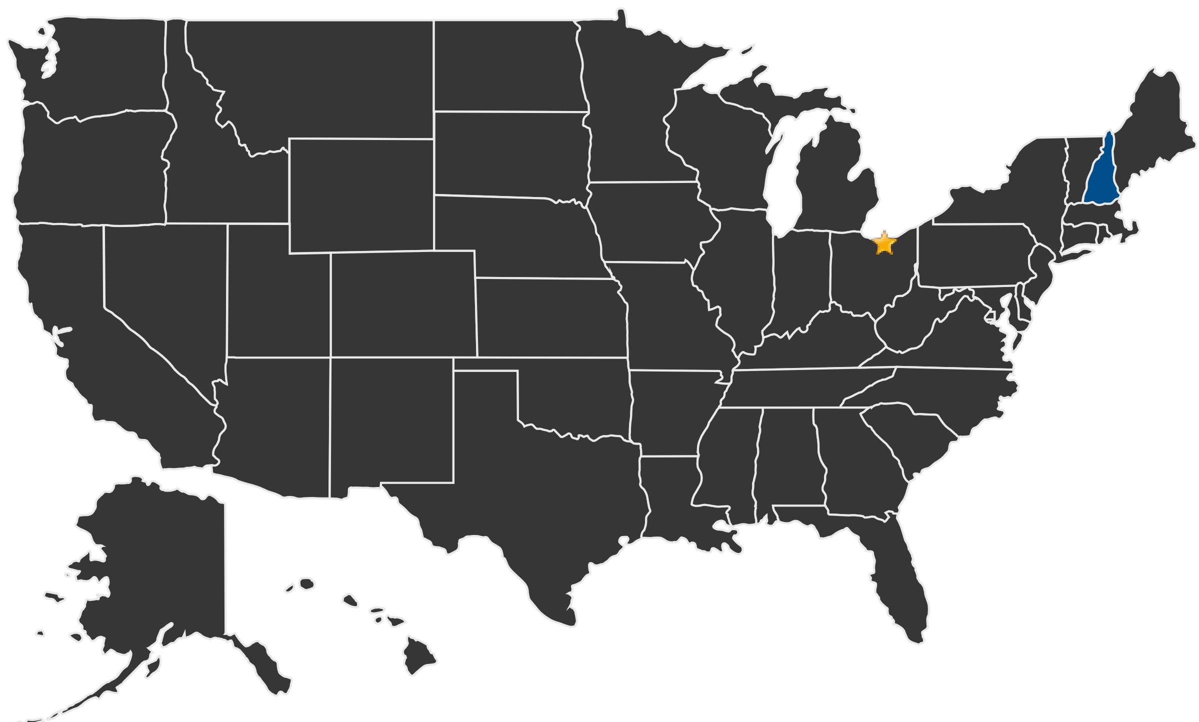
Management Team *(cont.)*

Principal Investigator:

- Mark Zagarola

operating temperature of these systems makes the cryocooler a critical component of any solution. There is also a large potential market beyond superconducting applications, including cooling for laboratory and industrial-scale gas separation, liquefaction, cryogen storage and cryogen transportation systems, liquid hydrogen fuel cell storage for the automotive industry, and commercial orbital transfer vehicles and satellites.

U.S. WORK LOCATIONS AND KEY PARTNERS



U.S. States With Work

Lead Center:
Glenn Research Center

Other Organizations Performing Work:

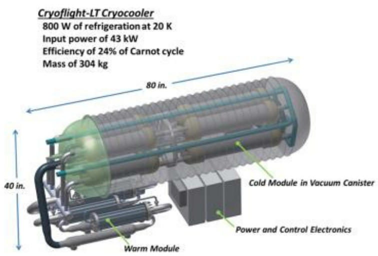
- Creare, LLC (Hanover, NH)

PROJECT LIBRARY

Presentations

- Briefing Chart
  - (http://techport.nasa.gov:80/file/23559)

IMAGE GALLERY



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DETAILS FOR TECHNOLOGY 1

Technology Title

A New Cryocooler for MgB2 Superconducting Systems in Turboelectric Aircraft, Phase II

Potential Applications

Our proposed cryocooler development effort will support NASA?s long-term goal to increase aircraft efficiency and reduce aircraft emissions and noise. By providing a cryocooler capable of cooling MgB2 systems and optimized to meet the aggressive power density target required for aircraft, we will enable an alternative approach to HTS systems and allow a detailed evaluation of the relative advantages of HTS and MgB2 superconducting technologies. Such an evaluation is needed to clarify the road map for superconducting aircraft. While such aircraft are still two or three decades from production, supporting technology development needs to begin now if such aircraft are to become a viable alternative to the aircraft configurations in production today. The results of this SBIR project will support continuing NASA design trade studies, system demonstrations, and eventual superconducting aircraft demonstrations. Other NASA applications include space applications such as hydrogen cryogenic liquefaction and zero-boil-off storage for in-space propellant depots, planetary and extraterrestrial exploration missions, CEVs, extended-life orbital transfer vehicles and extraterrestrial bases. Terrestrial NASA applications include cooling for spaceport cryogen storage and transportation systems and for demonstration hydrogen production and transportation systems. The highly reliable and space-proven turbo-Brayton cryocooler is ideal for these applications.